NEED FOR RESOLUTION OF MUSICAL INTERVALS

Part I: Static Context[1]

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A mystery of long-standing interest to psychologists and musicologists alike concerns the identification of the determinants of the (presumably singular) experiential state variously called, in the West, completeness, concordance, harmony, equilibrium, restfulness, and resolution, but most commonly, "consonance".

Although the search for the basis of *consonance* commenced over 2000 years ago with Pythagoras, no totally unobjectionable formulation has as yet been advanced. The early theories fell into four main categories (see Berlyne, 1971, Guernsey, 1928, or Lundin, 1953, for summaries).

Some writers based the phenomenon upon the instantaneous apprehension of complex mathematical relationships obtaining between the simultaneous tones. Some equated *consonance* with the absence of "beats" between the concurrent tones, and dissonance with their presence. Others based theories upon the degree to which the component tones were perceived as "fusing" into a single acoustic percept. Still others postulated genetic transmission of acquired musical 'tastes'.

More recent work has indicated that *dissonance*, at least, could be related to patterns of actual physical interference between adjacent areas of excitation of the ear's basilar membrane (Levelt and Plomp, 1968). It is not the purpose of the present article to enter what might be termed "the psycho-acoustic substrate of consonance quandary" (Maher, 1975). Rather, the present paper is a report of the first of a series of experiments designed to explore possible cultural correlates of reactivity to elementary acoustic events, such as would normally be heard in actual musical works.

Owing to anticipated difficulties in translation and intelligibility of musical terminology to musically untrained individuals, it was deemed necessary to find some easily comprehended and readily translated concept that individuals sampled from widely disparate cultures could meaningfully use in describing their 'musical' experiences. In this regard, the *consonance-dissonance* construct, although widely favoured by musicians, is of questionable utility in experimental work for numerous reasons. For one thing, investigations have shown that 'consonance' has different connotations for different people (see Berlyne, 1971: 241). Furthermore, the concept is such a nebulous one at best, that, on intuitive grounds, an accurate translation into another tongue would seem extremely unlikely.

If it can be assumed that the lengthy string of *consonance*-related terms listed in the first sentence of this introduction all derive from the same psychological condition of the listening organism, perhaps a non-technical alternative terminology will present itself if the experiential condition common to these varied pronouncements can be identified. Consider the following remarks : (italics added).

> Dissonant chords... arouse a feeling of *unrest* and dissatisfaction, *calling for further motion* towards something satisfactory (Schoen, 1940:61).
>
> . . . the critical determinant of consonance and dissonance is expectation of *movement*. . . . A consonant interval is one which sounds stable and complete in itself, which does not produce a feeling of necessary movement to other tones. *A dissonant interval causes a restless expectation of resolution, or movement* to a consonant interval (Cazden, 1945:5).

Such notions of "unrest" and "expectation of movement" associated with the experience of the musical intervals are frequently encountered in the West. These tensions and their implied resolutions have been described as the *fundamental* relationships in music by some Western writers (e.g., von Hoeslin, quoted in Langer, 1957:227). Significantly, similar opinions have been expressed with regard to the modal music of India :

> . . . the primary significance of the various intervals is their relationship to the ground-note. . . . Only the ground-note [*Sa*] is at *rest* and needs no completion. All other intervals manifest *instability*, each to its own particular degree. . . (Jairazbhoy, 1971:65).

It seems likely, therefore, that the perception of the need for movement, or *need for resolution* of a musical interval is a fundamental feature common to the Indian and Western experiences of these elementary components of melodic music. Under this assumption, the consonance-dissonance construct was abandoned and a more parsimonious Need For Resolution (*NFR*) construct was adopted for use in all the investigations to be reported in this series. Individuals were asked to describe the musical interval stimuli with reference to the readily translated *Restfulness-Restlessness* continuum.

Despite the relatively wide variation found in responses to the other musical intervals, most of the Western experimental data concur in according the seconds (*Re* and *Re komal*) and the sevenths (*Ni* and *Ni komal*) an especially 'dissonant' status (Berlyne, 1971; Kreitler and Kreitler, 1972). It is generally accepted that such *dissonances* can promote feelings of tension and irritability — consider the numerous references in popular literature to the unbearable anguish supposedly suffered by the family of the aspiring young violinist! Some measure of support for this presumed influence of *dissonance* upon the body's arousal system has recently accrued from electroencephalograph research (Berlyne et al, 1967).

Lundin's "cultural theory of consonance" (1947) suggests that a population exposed frequently to seconds and sevenths, for instance, would be inclined to experience those intervals as less 'dissonant' than would a less familiar population. Cazden (1945:5) supports this view, arguing that "the resolution of intervals does not have a natural basis; it is a common response acquired by all individuals within a culture-area."

It is interesting to note that a number of Indian *ragas*, especially those in *Marva, Purvi,* and *Tori thats,* emphasize the very intervals considered to be the most 'dissonant' in the West (as outlined above, with the addition of the augmented fourth, *Ma tivr*). Although these *ragas* are not generally considered to be particularly tension-ridden in India,[2] it would not be surprising if the Western listener were to find them somewhat distressing, considering the apparent effect of exposure to prolonged *dissonance*. Indeed, there is some experimental evidence that Indian and American listeners differ in their reactions to Indian classical *ragas* (Keil and Keil, 1966).[3]

We are thus faced with the possibility that the Indian listener experiences the very raw materials of music, the musical intervals, in a fundamentally different way than does the Western listener. The first experiment in this series was designed to determine whether Indians and Canadians differ in their experiences of the *Need For Resolution* of simultaneous musical intervals. Verbal responses on an Osgoode-type semantic differential continuum (Osgoode, 1952), labelled "Restful" at one pole and "Restless" at the other, were taken as an index of perceived *NFR*. The Indian results of the experiment will be reported in this article.

There are, however, other explanations for differences in the Western and Indian appreciations of Indian *ragas*. Perhaps both types of listener experience the musical intervals in the same manner, but some other feature (or features) of North Indian classical music interacts with these apparent sources of tension-'induction' (Berlyne, 1971, Berlyne et al, 1967) to produce, at least for the initiated listener, an overall experience that is qualitatively different from that suggested by its *static* component parts. Jairazbhoy (1971) has described a melodic mechanism, *melodic symmetry,* that could conceivably militate against (and perhaps temporarily eliminate) the normal tendency of *dissonant* intervals to 'induce' tension. Interestingly enough, this theory predicts that in certain contexts, the normally *consonant* intervals could temporarily appear to be extreme *dissonances.*

A preliminary report of an experiment designed to determine the influence of melodic symmetry on judged *NFR* of specific musical intervals will be reported in the second of these two articles dealing with the reactions of Indian individuals.

METHOD

Subjects. The experimental *subjects* were 123 female undergraduates enrolled in introductory-level psychology courses. Staff members of the following Poona institutions arranged for their availability :

The Maharashtra Education Society's Abasaheb Garware College
Modern College
The S.N.D.T. College for Women

Although the experimental design required 8 *subjects* per group, superfluous subjects were not excluded from the experimental sessions.[4] As it turned out, the 12 groups ranged from 9-14 *subjects* in size.

Apparatus. The tonal materials were generated with an Indian harmonium made by A.S. Mirajkar. A Beyer M160 microphone was stationed upside-down directly over the case's reed vents. A Nagra IV-L tape recorder was used to record the harmonium tones.

The test tapes were generally played to the subjects on an Uher 4000 tape recorder. On occasions when that machine was not available, the Nagra, an Uher 4400, or a Philips tape recorder was used.

Instructions to the *subjects* were generally read by a native-speaker; for the one occasion on which this was not possible, the same instructions were presented via a portable cassette recorder.

Stimulus Construction and Experimental Design. The 12 musical intervals used as stimuli were formed by pairing each of the 12 semi-tones within the octave *F-f* with the common base-note *F* as *Sa* (white-4 on the harmonium). The drone note was sounded continuously during recording by activating a stop on the keyboard. Each of the two-note chords, consisting of the drone and one of the 12 semitones, was of 5 seconds duration, and there was a gap of 10 seconds between each chord during presentation.

It was considered likely that the particular sequence in which the intervals were presented, and the particular temporal position occupied by each interval within that sequence, would influence the rating responses obtained. For these reasons, the intervals were ordered for presentation according to a different row of the 12 × 12 *Williams Balanced Latin Square* for each group (Edwards, 1971:193). Any Latin Square design ensures that each experimental condition will occur equally often in each temporal position; the desirable property of this specialized Latin Square is that every stimulus condition precedes every other condition *equally often,* when the entire square is considered.

TABLE I

Presentation Orders of Musical Intervals
(all notes paired with *Sa* drone; t=tivr, k=komal).

	Stimulus Temporal Position												
Group	1	2	3	4	5	6	7	8	9	10	11	12	13
1	D	Gk	Dk	Mt	Rk	Ś	G	P	Nk	N	R	M	M
2	Gk	Mt	D	Ś	Dk	P	Rk	N	G	M	Nk	R	R
3	Mt	Ś	Gk	P	D	N	Dk	M	Rk	R	G	Rk	Nk
4	Ś	P	Mt	N	Gk	M	D	R	Dk	Nk	Nk	G	G
5	P	N	Ś	M	Mt	R	Gk	Nk	D	G	Dk	Rk	Rk
6	N	M	P	R	Ś	Nk	Mt	G	Gk	Rk	D	Dk	Dk
7	M	R	N	Nk	P	G	Ś	Rk	Mt	Dk	Gk	D	D
8	R	Nk	M	G	N	Rk	P	Dk	Ś	D	Mt	Gk	Gk
9.	Nk	G	R	Rk	M	Dk	N	D	P	Gk	Ś	Mt	Mt
10	G	Rk	Nk	Dk	R	D	M	Gk	N	Mt	P	Ś	Ś
11	Rk	Dk	G	D	Nk	Gk	R	Mt	M	Ś	N	P	P
12	Dk	D	Rk	Gk	G	Mt	Nk	Ś	R	P	M	N	N

Thus, if the minor second interval (*Re komal*), for example, tends to render any immediately following interval more *restful* sounding, by a constant amount, than it would have sounded otherwise,this influence upon judged *NFR* will equally affect ratings of all the other intervals (since the minor second precedes each of them), and distorted estimates of their relative "restfulnesses" will not result.

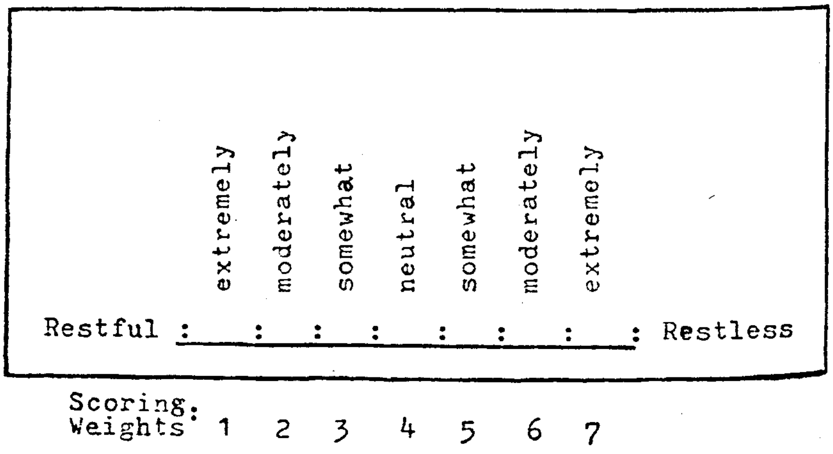
In order to facilitate the estimation of these *residual effects* of musical intervals, so that they could be statistically removed after the data had been collected, the final column of the balanced square was replicated, making it a

Williams Extra-Period Balanced Latin Square (Williams, 1949). This modification renders the statistical estimation of "direct" and "residual" effects of musical intervals completely *orthogonal* (Cochran and Cox, 1957), so that they can be assessed with equal precision. The experiential significance of this move was that every group of subjects heard, as their 13th stimulus interval, a repetition of their 12th musical interval. (see Table 1).

Procedure. The experimental *subjects* were run in groups of 9-14 in Poona classrooms. The tape recorder was positioned so as to project approximately equally to students occupying various positions in the room. The following is a 'back'-translation of the Marathi instructions.

> The purpose of this experiment is to study how different people react to musical notes. In order to measure the reactions of individuals to environmental events, psychologists use a tool, known as the 'Rating Scale'. A rating scale is a dimension spreading to the extreme, opposite ends of any particular characteristic. This dimension is divided into a few categories by verbal definitions indicating different degrees of that particular characteristic. We can communicate our reactions more clearly and precisely by indicating where exactly our reactions are placed along this dimension.
>
> In this experiment, we are going to use one such rating scale to study your reactions to some notes played on the harmonium.

The *subjects* were asked to look at their mimeographed response sheets, and the *experimenter* translated the English terms. A portion of a typical answer sheet is reproduced in Figure 1.



extremely moderately somewhat neutral somewhat moderately extremely

Restful : : : : : : : : Restless

Scoring Weights: 1 2 3 4 5 6 7

Figure 1. Sample portion of a *Restfulness-Restlessness* rating scale response sheet.

> . . Your reactions to the 13 notes that you are going to hear played on the tape recorder should be entered one by one in every row. When you hear each note, your reaction to that note should be entered under the category that best describes it. For each note make only one entry, exactly under the category heading. Please do

> not erase the marks you make. There is no question of your reactions being right or wrong. We are interested in whatever reactions you have in response to these notes. It is, therefore, essential to record your own reactions, without referring to anyone else's.
>
> Now you will hear 13 notes. Enter your reactions in the *restful-restless* dimension, as explained earlier. Each note will be played for 5 seconds. In the 10 second interval that follows, enter your reactions. Do this immediately and carefully, so that you are ready to hear the next note.
>
> If you are familiar with any system of notation, write the names of notes along with your category mark.[5]

The tape recorder was activated at this point, and the *subjects* proceeded to record their ratings on the response sheets. After the final "note" had been rated, two questions were translated from the response sheet. One required the *subject* to indicate the amount of difficulty she had experienced in making the ratings, while the other requested an indication of the amount of 'systematicness' or 'randomness' she had felt in responding. The tape was rewound during this period.

> In this section, you will hear 13 more notes, and you have to record your reactions as you have done before.

During this period, the same 'notes' were rated in the same sequence; this procedure was adopted in order to maximize the probability that every *subject* would provide some usable information to the survey.[6]

RESULTS

Intonation. For purposes of later electronic analysis, extended recordings of the individual notes used in forming the stimulus intervals were made in India on the Nagra tape recorder. These harmonium materials were played back and analyzed for fundamental-note frequencies at the Universities of Windsor and Toronto.

The tape was played back on a TEAC tape recorder (model 2300s) and the signals were channelled via a band-pass filter (Krohn-Hite, model 3343, adjusted to pass 300-800cps) to an electronic frequency counter (Hewlett-Packard, model 5512a).

Table 2 compares the intonation of the harmonium with the theoretical Pythagorean and Just values. Although the observed departure from either system is rather small, the minor second (*Re komal*) and the major third and sixth (*Ga* and *Dha*) are closer to just intonation, whereas the minor versions of the latter two intervals (*Ga komal* and *Dha komal*) are more similar to the Pythagorean values.

TABLE 2

India Harmonium Intervals Compared to Theoretical Values
(F=342 cps; values are given in *cents*).

Interval	Harmonium	Pythagorean	Divergence	Just	Divergence
F—G^{b}	94	90	+ 4	112	—18
F—G	200	204	— 4	204	— 4
F—A^{b}	296	294	+ 2	316	—20
F—A	388	408	—20	386	+ 2
F—B^{b}	499	498	+ 1	498	+ 1
F—B	590	588	+ 2	590	0
F—c	704	702	+ 2	702	+ 2
F—d^{b}	795	792	+ 3	814	—19
F—d	890	906	—16	884	+ 6
F—e^{b}	998	996	+ 2	996	+ 2
F—e	1093	1110	—17	1088	+ 5
F—f	1200	1200	0	1200	0
	Total Divergence		73 cents		79 cents

Apart from the one interval, G-d (*Re-Dha*) of 690 *cents*, the harmonium tuning of fourths, fifths, and octaves was quite accurate; the maximum deviation from the theoretical being generally less than 5 *cents*.[7]

Comment. The accuracy of the instrument's 'internal' tuning was quite impressive; deviations of the order observed could easily arise from irregular pumping of the bellows, or slight innacuracies of the equipment used to record and analyze the intervals. The mixture of Pythagorean and Just tuning systems observed with this instrument is of particular interest, since such a system does not seem to have been noticed by other scholars. However, it is very probable that each individual harmonium has its own tuning, and that none is likely to be in perfect accord with either tuning system.[8]

Restfulness-Restlessness Ratings

Direct Effects. In statistical terminology, an experimental effect that is likely to occur less than or equal to 5% of the time by 'chance' ($p \leqslant .05$) is called a "significant" or a "reliable" effect. The design of the present experiment allows the assessment of the *statistical significance* of differences obtained in ratings due to the following influences :

1 The influence of the experimental time period (1-13) in which the rating was obtained (the *Periods* effect).

2 The influence of individual differences in subjects making up the 12 experimental groups (the *Groups* effect).

3 The influence of the stimulus interval presented for rating (the *Direct* effect of musical intervals).

4 The influence of the stimulus interval presented for rating upon the immediately subsequent interval rating (the *Residual* effect of musical intervals).

5 The influence of unforeseen factors, or unexpected interactions of the recognized factors (the *Remainder* effect).

This concept of statistical significance is of paramount importance in experimentation, since it provides objective decision rules to be used in assessing the results of an investigation such as this one.

An analysis of variance for the *Williams Extra Period Balanced Latin Square* (Cochran and Cox, 1957) revealed a significant *Remainder* effect, of a magnitude expected in one out of every 100 experiments by 'chance' ($p<0.1$). This finding was taken as an indication that the model adopted for the experiments, viz., that ratings would be significantly affected only by the first four of the five possible influences listed above, was incorrect. The presence of the unexpectedly large *Remainder* effect necessitated the use of conservative procedures in the appraisal of the other experimental effects.[9]

The effect due to differences between *Groups* of subjects was statistically reliable ($p<.005$), as was the *Direct* effect of musical intervals ($p<.05$). No other effects were statistically significant.

Figure 2 summarizes the results of the experiment. The overall mean *Restfulness-Restlessness* rating (based on 96 *subjects*) is expressed for each interval as a deviation from the overall mean of all interval means.[10] Negatively directed vectors indicate displacements towards the *Restful* end, and positively directed vectors displacements towards the *Restless* end, of the rating continuum. The length of each vector represents the extent of its interval's deviation from the 'grand mean' of the twelve intervals, in rating scale units.

Duncan's *new multiple range test* (Edwards, 1971: 131) was employed to establish which differences among mean ratings for stimulus intervals accounted for the significant effect detected by the analysis of variance. It revealed that the augmented fourth (*Ma tivr*), minor sixth (*Dha komal*), and seventh (*Ni*) were rated as significantly ($p<.05$) *more Restless* than the third (*Ga*) and octave (*Sá*).

The intervals least in need of resolution (that is, judged most *Restful*), in rank order, are as follows : the octave (*Sá*), the third (*Ga*), the minor seventh (*Ni komal*), the fifth (*Pa*), and the minor third (*Ga komal*).

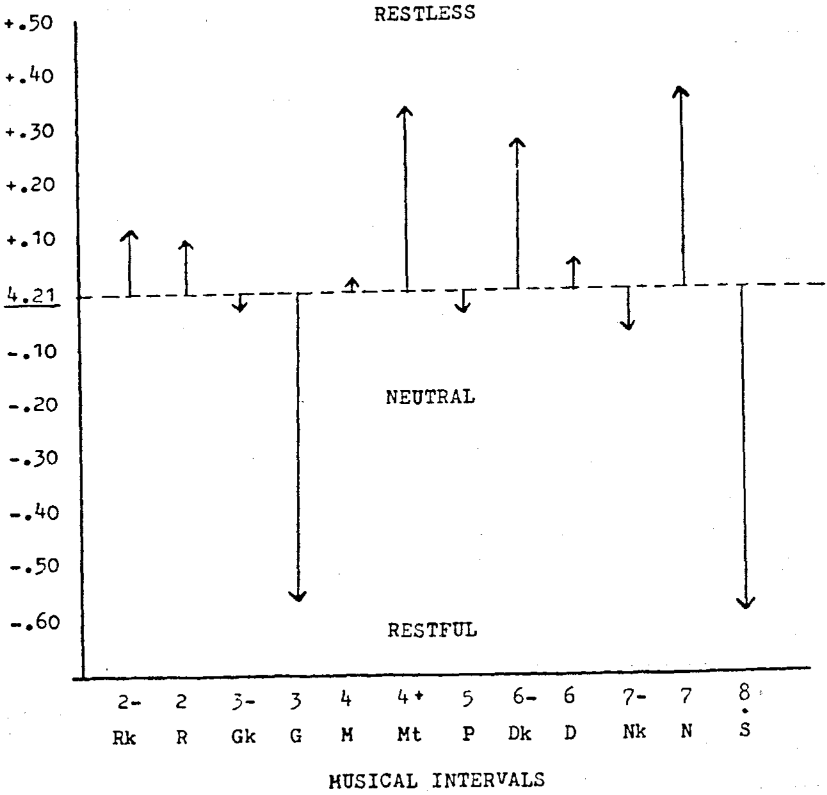


Figure 2. Mean *Restfulness-Restlessness* ratings of musical intervals expressed as scale-point deviations from the average of mean interval ratings.

The intervals most in need of resolution (that is, judged most *Restless*), in rank order, are: the seventh (*Ni*), the augmented fourth (*Ma tivr*), the minor sixth (*Dha komal*), the minor second (*Re komal*), the second (*Re*), the sixth (*Dha*), and the fourth (*Ma*).

Comment. There are several possible explanations for the significant amount of *"Remainder"* variation revealed by the analysis of variance. Since several tape recorders were used in the course of the experiment, it is likely that the particular acoustic properties of each machine flavoured the impressions experienced by the *subjects*, such that the rated Restlessness of an interval was in part a function of the apparatus used for a particular experimental session. The fact that the Canadian experimenter was not present for some of the sessions suggests that a 'foreigner effect' might have influenced some, but not all of the ratings — thus interjecting another source of variation into the overall situation.

The musicologist will readily apprehend some familiar patterns, *and* some rather curious departures from familiar patterns, in the *Need For Resolution* estimates obtained. Although the octave (*Sá*) and the seventh (*Ni*) emerge at the extreme ends of the continuum, as would be anticipated, the minor sixth (*Dha komal*) received an unusually *restless* rating. In addition, it is somewhat surprising that the 'perfect' fifth (*Pa*) was not rated as a more *restful* note. There could be a number of explanations for this finding. It is possible that individuals accustomed to hearing the 5th as a prominent component of the *drone* in the music of their culture cannot conceive of that interval in terms of a *NFR* continuum; the markedly neutral rating obtained for that interval in the present study certainly attests to that possibility. Alternatively, it is possible that some deficiency of the harmonium or the record/playback apparatus could account for this apparent anomaly. If, for example, the second overtone (third harmonic) of the *F* drone, which produces the note *c* (*Pa*), were weak in playback, the keyboard *c* (which produces the 5th) might have been rendered less *restful*-sounding as a consequence.

Apart from this, it would appear that the pattern of response by Indian *subjects* to these *static context* intervals is not appreciably different from what one would expect of Western *subjects*. Certainly, some of the intervals expressing the greatest *need for resolution,* such as the major seventh (*Ni*) and the augmented fourth (*Ma tivr*), seem quite comparable.

Correlational Analyses : As an aid to the interpretation of these findings, the musical intervals were rank-ordered from most *Restful* to most *Restless,* and that ordering was compared to others derived from studies reported in the Western literature. Spearman's rank-order correlation coefficient (Ferguson, 1971:305) was calculated for each of the three rank orderings listed in Table 3 in comparison with the results of the present experiment. This statistic yields a value of + 1.00 when identical rank-orders are compared,—1.00 when one order is exactly reversed relative to the other, and an expected value of zero when the two rank-orders are entirely dissimilar.

Table 3 shows that the rank ordering of American *Pleasantness* judgements for organ-pipe intervals correlates significantly positively ($p<.05$, by "t"-test) with the Indian harmonium interval ratings. However, smaller, *negative* correlations emerge when these Indian data are compared with Dutch ratings of sine-wave intervals.

Comment. Although the present authors know of no Western study exactly comparable to this Indian one, it was thought that comparisons with similar studies could be potentially enlightening. The investigations represented in Table 3 were selected because they also used verbal measures in gathering response-data pertaining to simultaneous musical intervals (investigations using paired-comparison-type designs were not considered).

TABLE 3

Rank Orderings of Musical Intervals
Obtained in Studies Using Verbal Measures

Rating :	*Restfulness*	*Pleasantness*[a]	*Quietness*[b]	*Passiveness*[c]
Subject Nationality	Indian	American	Dutch	Dutch
Tone Source	harmonium	organ pipes	sine-wave generators	
2—(Rk)	9	12	8	9
2 (R)	8	10	12	12
3—(Gk)	5	6	11	11
3 (G)	2	2	9	3
4 (M)	6	3	4	4
4+(Mt)	11	9	5	8
5 (P)	4	1	10	10
6—(Dk)	10	7	1	2
6 (D)	7	4	7	5
7—(Nk)	3	8	6	6.5
7 (N)	12	11	3	1
8 (Ś)	1	5	2	6.5
Spearman's $\rho=$		+.66	—.41	—.35

[a] From Guernsey, 1928, p. 191. 56 "musically untrained" subjects. Dependent measure: percentage of trials in which interval was called "pleasant".

[b] From van de Geer, Levelt, and Plomp, 1962, p. 310. 10 "intelligent" subjects, musically untrained. Dependent measure: *Quiet-Tense* rating scale response.

[c] op. cit. Dependent measure: *Positive-Active* rating scale response.

The fairly high correlation of Indian responses with American judgments of "Pleasantness" is interesting, but difficult to interpret, since the relationship of *pleasantness* to judged *NFR* is not known for Westerners *or* Indians. The two rank-orders differ most with respect to the minor seventh (*Ni komal*) and the octave (*Sá*), both being attributed higher ranks (lower numerical values) by the Indian group.

The comparisons with Dutch ratings would seem to be more pertinent, since these ratings were based on scale continua more closely related to the *Restful-Restless* dimension. However, the negative correlations found with these data sets indicate that the rank orderings are somewhat relative to the Indian data. This situation stems in large part from the high ranks attributed by Dutch subjects to the classically 'dissonant' intervals. Witness, for instance the rank of 1 on the *Passiveness* scale and the rank of 3 on the *Quietness* scale given the Major seventh (*Ni*); this interval was ranked 12th by the Indians for *Restfulness*, a presumably similar concept.

However, these Dutch findings are of doubtful relevance to music in general, since in the same sine-wave study *subjects* rated the augmented fourth (*Ma tivr*) and the minor sixth (*Dha komal*) as the most "consonant" of intervals; findings that any music theorist would find extremely difficult to assimilate.

Residual Effects. Although the musical intervals did not significantly differ with respect to their *Residual* effects, those effects will be reported here due to their potential import and the novelty of their isolation.

Figure 3 depicts the estimated *residual effects* of the various musical intervals. A negative vector associated with a given interval indicates that the next interval rated will, on the average, be judged more *Restful* than it would have been otherwise; similarly, a positively directed vector indicates that the next rating will be biased towards the *Restless* end of the scaling continuum The magnitude of the estimate indicates the average magnitude of the *residual effect* in rating scale units (see Cochran and Cox, 1957, Edwards, 1971, or Williams, 1949, for details).

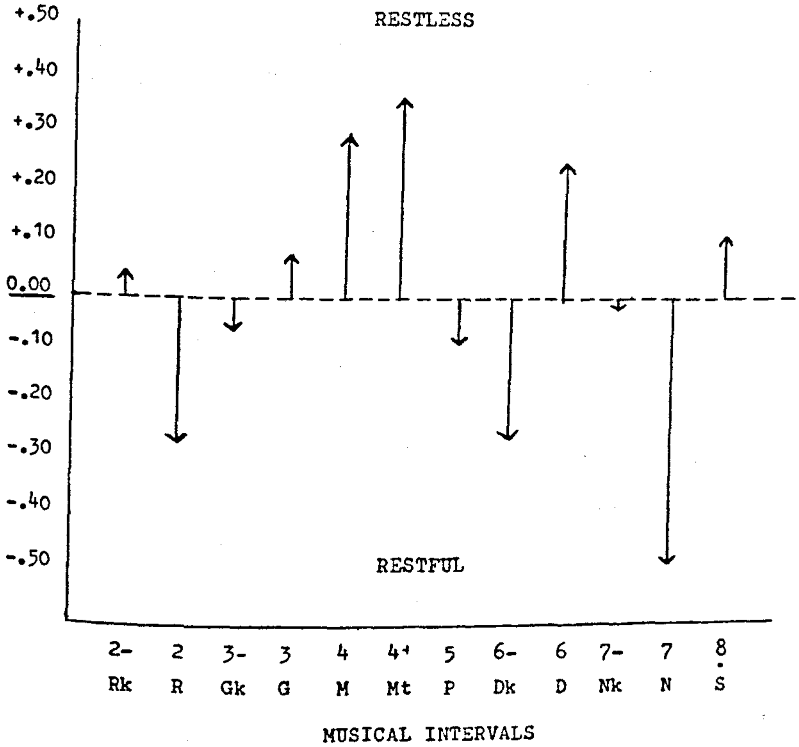


Figure 3. Estimated *residual effects* of musical intervals upon immediately following *Restfulness-Restlessness* ratings of other musical intervals, expressed in rating-scale units.

Rated intervals that influence subsequent interval's ratings in the *Restful* direction are, in order of the magnitude of the affect exerted, the seventh (*Ni*), the second (*Re*), the minor sixth (*Dha komal*), the fifth (*Pa*), the minor third (*Ga komal*), and the minor seventh (*Ni komal*).

Intervals biasing subsequent ratings toward the *Restless* end of the scaling dimension are, in order of the extent of their influence, the augmented fourth (*Ma tivr,*) the fourth (*Ma*), the sixth (*Dha*), the octave (*Sá*), the third (*Ga*), and the minor second (*Re komal*).

Comment. The *residual effect* estimates, although not statistically reliable, are rather interesting. It appears that prior exposure to a musical interval may have some affect upon the rating given to the next interval; although there is no clear pattern emerging from these results, there seems to be an indication that *restless* intervals tend to make the following interval seem more *restful.* This is apparently the case with the major seventh and second, although the augmented fourth has the opposite affect, and the minor second (*Re komal*) seems to have virtually no affect.

CONCLUSIONS

Although no conclusive results can be advanced on the basis of this one investigation, the authors consider this study to be noteworthy for several reasons.

Methodology

The importance of experimental influences that are commonly underestimated was indicated. There is reason to suspect that such factors as the acoustic idiosyncracies of different tape recorders and the presence or absence of a 'foreigner' in the experimental situation affected the rating scale responses obtained.

This experiment is apparently the first in the area of the psychology of music that has allowed the estimation of the contamination of response measures resulting from *residual effects* of one stimulus condition upon another. Although the temporal parameters arbitrarily chosen for stimulus duration and inter-stimulus-interval were apparently sufficient to virtually eliminate such effects in the present experiment, it is important to have a measure of the extent of such contamination, since arbitrary design decisions cannot be trusted to control these influences.

Musicology

Although harmonium tunings are known to vary quite considerably, this investigation has indicated that there may be a tendency for Indians to prefer the Just Intonation tunings of the major third and sixth and the Pythagorean tunings of the minor third and sixth.

Although the Indian ratings of the *static context* musical intervals for *Need For Resolution* seem, on intuitive grounds, to be in accord with the general emphasis of Western music theory, there are no experimental data strictly comparable with which to effect a cross-cultural comparison. Therefore, the question of the similarity of Indian reactions to Western reactions with regard to the musical intervals must await resolution from further research.

The music-theoretic notion that melodic context greatly influences the *consonance-dissonance* functions of individual intervals received suggestive support from the present investigation. Since in actual musical works notes and chords are not heard in isolation, we can infer that *residual effects* of musical intervals constitute an even more influential factor outside the experimental situation.

While the results of this preliminary study are by no means conclusive, they do provide sufficient baseline data for a more ambitious experiment to be reported in a subsequent article, which was specifically designed to explore some of the influences of melodic *contexts* on judged *Need for Resolution* of particular musical intervals.

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NOTES

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2. According to Kaufmann (1968), for instance, one of *raga Marva's* characteristics is an expression of "quiet, tender love" (p. 315), while *Tori* is said to represent "the mood of delighted adoration in a gentle, loving sentiment" (p. 551) and *raga Purvi* "has a deeply serious, quiet and somewhat mysterious character" (p. 277).

3. Unfortunately, methodological problems cast doubt upon the credibility of these results. For example, stimulus effects (recorded excerpts of Indian classical *ragas*) were confounded with effects due to the order of presentation of the stimuli and the 22 rating scales.

4. Data sheets were randomly discarded until 8 remained for each group. All analyses were performed upon these 96 sets of observations.

5. It was considered that identification of intervals might predispose *subjects* to respond in traditional music-theoretic terms, and for that reason, it was considered potentially useful to have this added information. Since only 3 out of 96 *subjects* indicated interval recognition, these data were not taken into consideration.

6. As it turned out, many *subjects* experienced obvious difficulty during the first rating session, as evidenced by an abundance of missing and unintelligible responses, that dissipated by the next session. This situation is reflected in the 'task difficulty' response data: the mean was 3.84 for session 1, and 3.13 for the second session (1 = Extremely Easy, 7 = Extremely Difficult). For this reason, only session 2 data are considered here.

7. It is interesting to note, however, that the drone *F* of the harmonium stop was 3 *cents sharp* relative to the keyboard *F* (although pitched one octave lower).

8. This harmonium was especially tuned by Mr. Satyasheel Deshpande.

9. *Mean Square Remainder* was used as the denominator in forming all subsequent *F*-ratios.

10. Since the *Residual* effects were not statistically significant, the *Direct* effect means were not adjusted to compensate for their impact

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